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⑬ 混成繊維強化プラスチック成形品

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明 細 書

1. 発明の名称

混成繊維強化プラスチック成形品

2. 特許請求の範囲

(1) 断面略一定の長尺状であり、その長手方向に繊維が断面中に埋設固定されている混成繊維強化プラスチック成形品において、

前記繊維は、弾性率の異なる少なくとも2種類の繊維から成り、

前記長尺状の成形品は少なくとも2層から成り、外周部には最も弾性率の高い繊維が埋設固定され、内層部には順次弾性率の低い繊維が埋設固定されていることを特徴とする混成繊維強化プラスチック成形品。

(2) 前記繊維は、炭素繊維、ポロン繊維、シリコンカーバイド繊維、アルミナ繊維、シリカ繊維、高配向高分子繊維、ガラス繊維の2種以上であり、前記樹脂は、エポキシ樹脂、不飽和ポリエステル樹脂、フェノール樹脂の1種である特許請求の範囲第1項記載の混成繊維強化プラスチック成形品。

ック成形品。

(3) 前記長尺状の成形品は、長手方向に中実である特許請求の範囲第1項記載の混成繊維強化プラスチック成形品。

(4) 前記長尺状の成形品は少なくとも3層から成り、最内層部には繊維が埋設固定されていない特許請求の範囲第1項記載の混成繊維強化プラスチック成形品。

(5) 前記長尺状の成形品は2層から成り、外周部には炭素繊維が埋設固定され、内層部にはガラス繊維が埋設固定されている特許請求の範囲第1項記載の混成繊維強化プラスチック成形品。

(6) 前記長尺状の成形品の断面形状は方形である特許請求の範囲第1項記載の混成繊維強化プラスチック成形品。

(7) 前記長尺状の成形品の断面形状は円形である特許請求の範囲第1項記載の混成繊維強化プラスチック成形品。

3. 発明の詳細な説明

本発明は、補強材として、少なくとも2種類の

Specification

1. Title of the Invention

Combined continuous fiber reinforced plastic molded article

2. Claims for the Patent

(1) A combined continuous fiber reinforced plastic molded article having an elongated shape with an approximately uniform cross-section wherein continuous fibers are embedded and immobilized in a resin in a longitudinal direction, characterized in

that said continuous fibers comprise at least two kinds of continuous fibers having different elastic moduli, and

that said molded article having an elongated shape comprises at least two layers, and continuous fibers having the highest elastic modulus are embedded and immobilized in the outer layer part, and continuous fibers having sequentially lower elastic modulus are embedded and immobilized in the inner layer part.

(2) The combined continuous fiber reinforced plastic molded article according to claim 1, wherein said continuous fibers are two or more of carbon fibers, boron fibers, silicon carbide fibers, alumina fibers, silica fibers, highly oriented polymer fibers and glass fibers, and said resin is one of epoxy resins, unsaturated polyester resins and phenolic resins.

(3) The combined continuous fiber reinforced plastic molded article according to claim 1, wherein said molded article having an elongated shape is hollow in the longitudinal direction.

(4) The combined continuous fiber reinforced plastic molded article according to claim 1, wherein said molded article having an elongated shape comprises at least three layers, and no continuous fibers are embedded in the innermost layer part.

(5) The combined continuous fiber reinforced plastic molded article according to claim 1, wherein said molded article having an elongated shape comprises two layers, and carbon fibers are embedded and immobilized in the outer layer part, and glass fibers are embedded and immobilized in the inner layer part.

(6) The combined continuous fiber reinforced plastic molded article according to claim 1, wherein the cross-section of said molded article having an elongated shape is rectangular.

(7) The combined continuous fiber reinforced plastic molded article according to claim 1, wherein the cross-section of said molded article having an elongated shape is circular.

3. Detailed Description of the Invention

The present invention relates to a combined continuous fiber reinforced plastic molded article with at least two kinds of continuous fibers as a reinforcing material.

A continuous fiber reinforced plastic (hereinbelow abbreviated as "FRP") is a composite material having a large number of continuous fibers as a reinforcing material embedded and immobilized in a plastic matrix. This is a material in which various characteristics such as stiffness of a plastic is

reinforced and improved with continuous fibers and has attracted attention particularly in late years as a reinforcement material having excellent characteristics and developments and researches therefor have been extensively conducted.

In order to impart such FRP with high stiffness, it has been conventionally required to embed and immobilize continuous fibers having high elastic modulus in a resin in a relatively large amount. However, generally the continuous fibers having high stiffness are expensive. Therefore, development of an FRP having relatively high stiffness in which used amount of continuous fibers having high stiffness is reduced has been demanded.

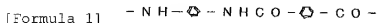
Under such circumstances, the present inventor has conducted studies and investigation in order to obtain an excellent FRP which is excellent in stiffness although used amount of continuous fibers having high elastic modulus is small. As a result, it has been discovered that, when continuous fibers having high elastic modulus are embedded in the outer layer part of a FRP molded article having an elongated shape even though continuous fibers having a relatively low elastic modulus are embedded in the inner layer part thereof, the flexural modulus of the FRP molded article as a whole is comparable with or only little inferior to that of FRP molded articles in which only continuous fibers having high elastic modulus are used. Based on this discovery, the present inventor has devised a combined FRP molded article having the following constitution.

The combined FRP molded article of the present invention has an elongated shape with an approximately uniform cross-section.

At least two kinds of continuous fibers having different elastic moduli are used as reinforcing materials for reinforcing the molded article. All of the plurality of continuous fibers are embedded and immobilized in a resin along the longitudinal direction of the molded article. The molded article of the present invention comprises at least two layers and continuous fibers having the highest elastic modulus are embedded and immobilized in the outer layer part and continuous fibers having sequentially lower elastic modulus are embedded and immobilized in the inner layer part.

The continuous fiber has a function to improve various characteristics such as stiffness of the FRP molded article as a reinforcing material. Various kinds of continuous fibers such as carbon fibers, boron fibers, silicon carbide fibers, alumina fibers, silica fibers, highly oriented polymer fibers and glass fibers can be selected and used as the continuous fibers depending on the use of the FRP molded article.

The highly oriented polymer fiber is a polymer fiber in which individual polymer molecules orient like rods as exemplified in Kevlar (trademark) whose unit molecular chain is represented by [Formula 1]. The mixing ratio between several kinds of continuous fibers used in combination as reinforcing materials and the contents thereof in the total amount of the continuous fibers in a FRP molded article are appropriately determined depending on the use of the FRP molded article.



The resin is a matrix of FRP or a base material in which continuous fibers are embedded and a suitable kind thereof is appropriately selected and used depending on the use of the FRP molded article. For example, various resins such as epoxy resins, unsaturated polyester resins and phenolic resins can be used.

The effect of the present invention can be exhibited more effectively when an epoxy resin, carbon fibers and glass fibers are combined together as a combination of these resins and the above mentioned continuous fibers. In this case, carbon fibers having high elastic modulus are embedded and immobilized in the outer layer part of the FRP molded article and glass fibers having a relatively low elastic modulus are embedded and immobilized in the inner layer part.

The combined FRP molded article of the present invention may be made hollow. Alternatively, the molded articles may be constituted of three or more layers, and no continuous fibers are embedded in the innermost layer part.

The cross-section of the combined FRP molded article may have various shapes such as a circular/rectangular shape depending on the use of the mentioned molded article. When the molded articles are produced by pultrusion molding method, the cross-section is determined by the cross-section of the die. For example, if the cross-section of the die is circular, cross-section of the molded article is circular, and when the cross-section of the die is rectangular, the cross-section of the molded article is rectangular.

The pultrusion molding method is a production method suitable for the production of FRP molded articles having an

elongated external form and the method is characterized in that a die (mold tool) having a through-hole of a certain shape is used. This is a production method comprising gathering a number of continuous fibers to spin rovings, impregnating the rovings with a resin and then aligning the rovings in a direction, and passing the aligned rovings continuously through the through-hole of the dice, curing the resin within the dice and taking out a FRP molded article having an elongated shape with an approximately uniform cross-section continually from the dice.

Before a resin impregnated continuous fibers are introduced into the dice when producing a combined FRP molded article of the present invention by pultrusion molding method, continuous fibers having high elastic modulus and continuous fibers having low elastic modulus are respectively disposed in the outer layer part and sequentially in the inner layer part.

The FRP molded article of the present invention has the following excellent characteristics.

Primarily, when a part of the continuous fibers having high elastic modulus are substituted with continuous fibers having low elastic modulus, decrease of the flexural modulus of the resultant combined FRP molded article is much less as compared with a ratio of the reduced continuous fibers having high elastic modulus. Therefore, if the continuous fibers having high elastic modulus are expensive, inexpensive FRP molded articles having a relatively high flexural modulus can be obtained by adopting the present invention. For example, the combined FRP molded article of the present invention containing 25 vol% of carbon fibers and 25 vol% of glass fibers maintains around 70%

of flexural modulus as compared with the conventional FRP molded articles containing 50 vol% of carbon fibers.

Secondly, as for the surface characteristics such as abrasion characteristics, the characteristics of the outer layer part of combined FRP molded articles are made use of as they are. For example, the combined FRP molded article of the present invention using carbon fibers in the outer layer part has excellent friction and abrasion characteristics and surface smoothness which are comparable to carbon fiber reinforced plastics.

Thirdly, the defects of the continuous fibers embedded and immobilized in the outer layer part can be supplemented by the continuous fibers embedded and immobilized in the inner layer part. For example, the glass fiber reinforced plastics are superior to carbon fiber reinforced plastics in impact strength. Therefore, the impact strength of the combined FRP molded article of the present invention in which carbon fibers are embedded and immobilized in the outer layer part and glass fibers are embedded and immobilized in the inner layer part is superior to that of the conventional FRP molded articles in which only carbon fibers are embedded and immobilized.

In the following, embodiments of the present invention are described.

Fig. 1 is a schematic view of an apparatus for producing FRP molded articles by pultrusion molding method. This production apparatus is composed of wind rolls 11, a resin impregnation tank 12 disposed on the right side thereof, that is,

sequentially in the moving direction of the continuous fibers and heating molding dice 13 and a taking-out apparatus 14.

The wind roll 11 is a member on which a roving 5 formed by gathering a number of continuous fibers to spin a yarn is set. The rovings 5 are sequentially and continuously drawn out from these wind apparatuses 11. The drawn rovings 5 are led into the resin 6 filled in the resin impregnation tank 12. At this time, the rovings 5 are guided into the resin 6 by plural control rolls 121 equipped in the resin impregnation tank 12. After a lot of the rovings 5 coated with a resin 6 are gathered and aligned in one direction, they are guided to heating molding dice 13 having a uniform cross-section. The resin is heated and cured in the heating molding dice 13. The thus produced FRP molded article 7 is continuously taken out of the heating molding dice 13 by the taking-out apparatus 14.

Example 1

A combined FRP molded article was produced having a rectangular cross-section by pultrusion molding method as shown in Fig. 2.

Carbon fibers 55 having a diameter of 7 μm and glass fibers 56 having a diameter of 10 μm are used as continuous fibers and an epoxy resin 61 is used as a resin. The content of the carbon fibers 55 in the combined FRP molded article was 25 vol% and that of the glass fibers 56 was the same.

Fig. 2 (a) is a cross-section of the combined FRP molded article 70 which is the product of Example 1 of the present invention. This has a structure having carbon fibers 55 embedded

and immobilized in the outer layer part and glass fibers 56 embedded and immobilized in the inner layer part.

Figs. 2 (b), (c) and (d) are cross-sections of the combined FRP molded articles 73 which were prepared to be compared with the combined FRP molded article of the above Example 1. (b) is a combined FRP molded article 73 in which the carbon fibers 55 and the glass fibers 56 are uniformly mixed and embedded and immobilized in the epoxy resin 61. (c) is a combined FRP molded article 73 in which the carbon fibers 55 are embedded and immobilized on the upper side and the glass fibers 56 are embedded and immobilized on the lower side. (d) is a combined FRP molded article 73 in which the glass fibers 56 are embedded and immobilized in the outer layer part and the carbon fibers 55 are embedded and immobilized in the inner layer part on the contrary to (a). These combined FRP molded articles 73 are different only in the combination form of the carbon fibers 55 and the glass fibers 56 from the combined FRP molded article 70 of Example 1 and the other conditions such as the fiber content in the combined FRP molded article are the same as the combined FRP molded article 70 in Example 1.

The combination forms of Figs. 2 (a), (b), (c) and (d) were realized by disposing the carbon fibers 55 and the glass fibers 56 at the time of alignment before the carbon fibers 55 and the glass fibers 56 were gathered and introduced into the heating molding dice 13 so that they may be in the form of Figs. 2 (a), (b), (c) and (d).

Here, the heating temperature of the resin in the heating molding dice 13 was 130°C and the heating time was 20 minutes.

The flexural modulus of the combined FRP molded article 70 of Example 1, namely (a) was 8.0 ton/mm². On the contrary, that of (b) was 5.8 ton/mm², that of (c) was 4.2 ton/mm², that of (d) was 4.6 ton/mm², which were comparative samples. In addition, the flexural modulus of the FRP molded article in which only 50 vol% of carbon fibers were embedded and immobilized was 12 ton/mm² while the flexural modulus of the FRP molded article in which only 50 vol% of glass fibers were embedded and immobilized was 2.5 ton/mm².

That is, the combined FRP molded article 70 of this Example 1 has flexural modulus superior to the comparative samples (b), (c) and (d). Besides, it has flexural modulus of a value close to 70% when compared with a FRP molded article in which only carbon fibers are used.

In addition, the impact strength of the combined FRP molded article of Example 1 is 170 kgcm/cm², and that of the FRP molded article in which 50 vol% of carbon fibers only are embedded and immobilized is 150 kgcm/cm².

Furthermore, the combined FRP molded article of Example 1 of the present invention had abrasion characteristics comparable to that of the FRP molded article in which only carbon fibers are used.

Example 2

Example 2 is approximately the same as Example 1. The point where Example 2 is different from Example 1 is that the cross-section of the combined FRP molded article was made circular as shown in Fig. 3. Fig. 3 (a) is a cross-section of the combined FRP molded article 70 of Example 2 of the present invention, and

Figs. 3(b), (c) and (d) are cross-sections of combined FRP molded articles 73 which were prepared to be compared with the combined FRP molded article 70 of Example 2.

The flexural modulus of the combined FRP molded article 70 of Example 2, namely that shown in Fig. 3 (a) was superior to those of the comparative samples (b), (c) and (d) in the same way as in Example 1.

In brief, the present invention is a combined FRP molded article having an elongated shape with an approximately uniform cross-section wherein continuous fibers having high elastic modulus are embedded and immobilized in the outer layer part, and continuous fibers having low elastic modulus are embedded and immobilized in the inner layer part.

As is apparent from the detailed description in the Examples, the combined FRP molded articles of the present invention are excellent FRP molded articles having relatively high flexural modulus, although they use a small amount of continuous fibers having high elastic modulus.

4. Brief Description of the Drawings

Fig. 1 is a schematic view of an apparatus for producing FRP molded articles by pultrusion molding method; Fig. 2 (a) is a cross-section of the combined FRP molded article of Example 1 of the present invention; Figs. 2 (b), (c) and (d) are cross-sections of the combined FRP molded articles which were prepared to be compared with Example 1; Fig. 3 (a) is a cross-section of the combined FRP molded article of Example 2 of the present invention; Figs. 3 (b), (c) and (d) are cross-sections of the

combined FRP molded articles which were prepared to be compared with Example 2.

11 ... Wind roll

12 ... Resin impregnation tank

13 ... Heating molding dice

14 ... Taking-out apparatus

55 ... Carbon fiber

56 ... Glass fiber

61 ... Epoxy resin

70 ... Combined FRP molded article

FIG. 1

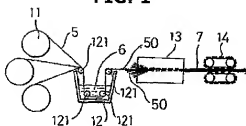


FIG. 2

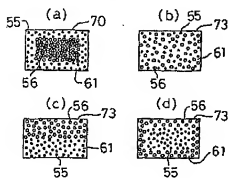


FIG. 3

